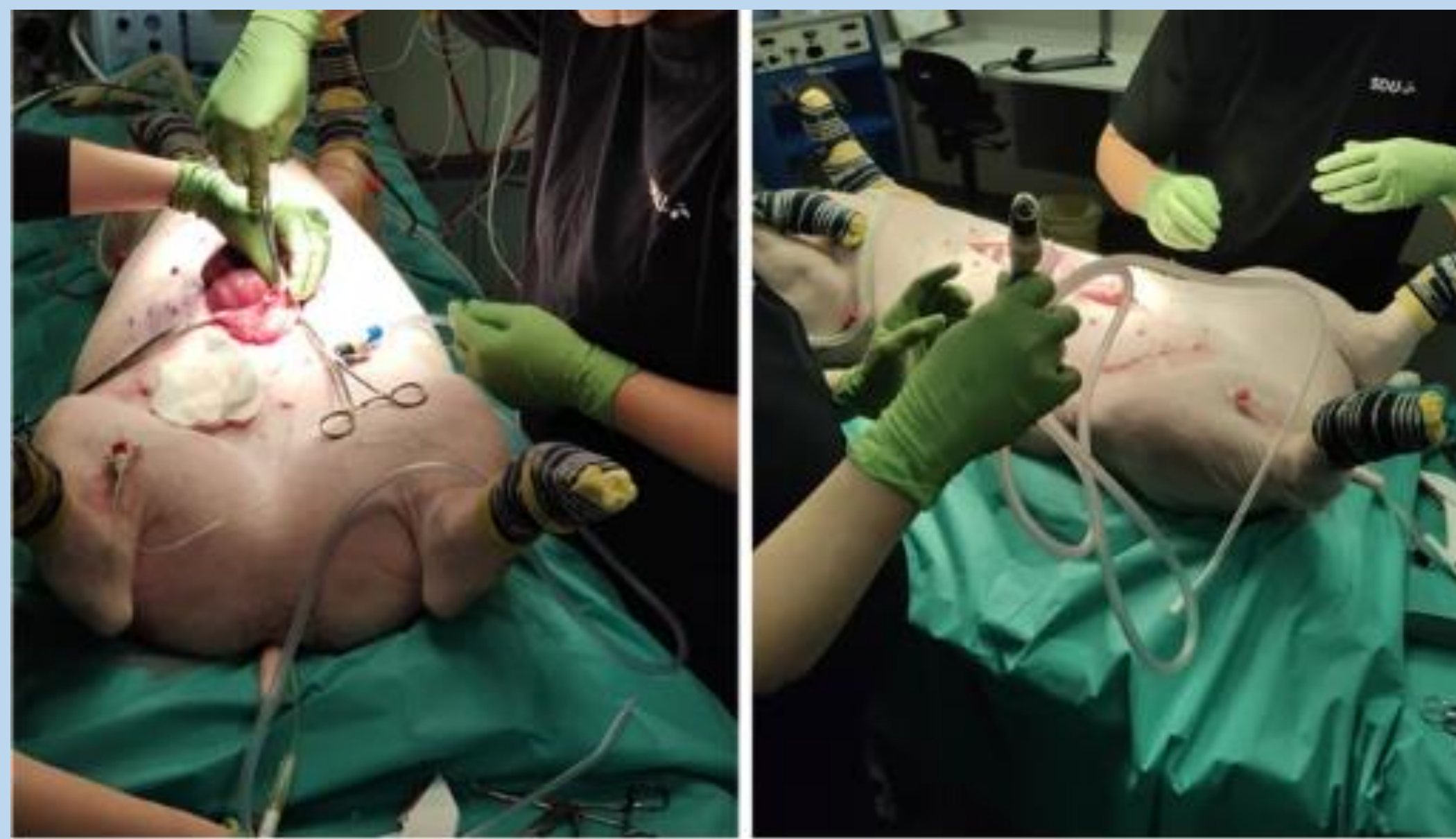


# MEM-44 Ingestible Electronics: A Capsule-Based Device for Detection in Viscous Biological Environments

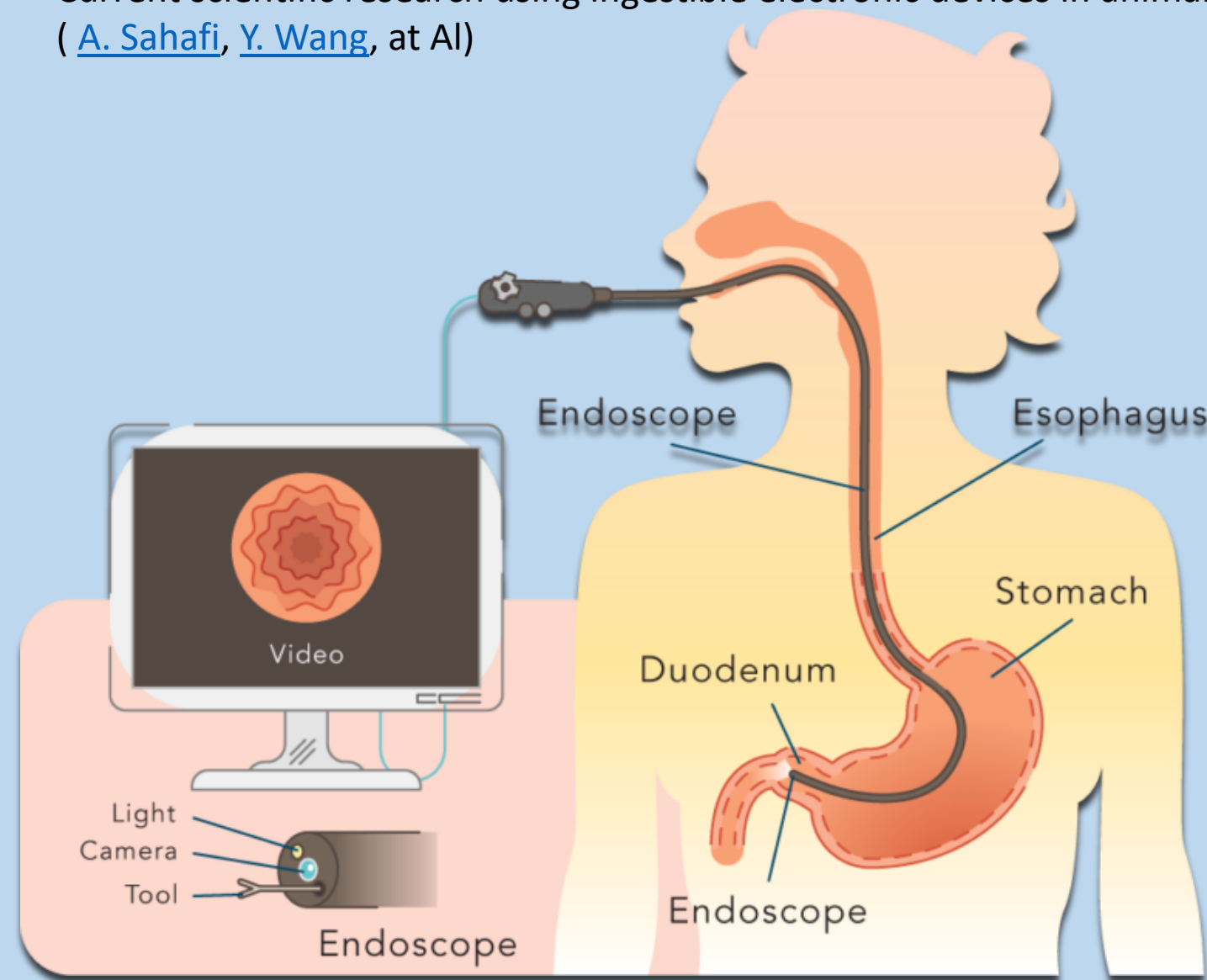
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(a) Pig under general anesthesia (left), our camera pill tethered prior to the insertion into pig's small intestine (right).

Current scientific research using ingestible electronic devices in animal testing (A. Sahafi, Y. Wang, et al)



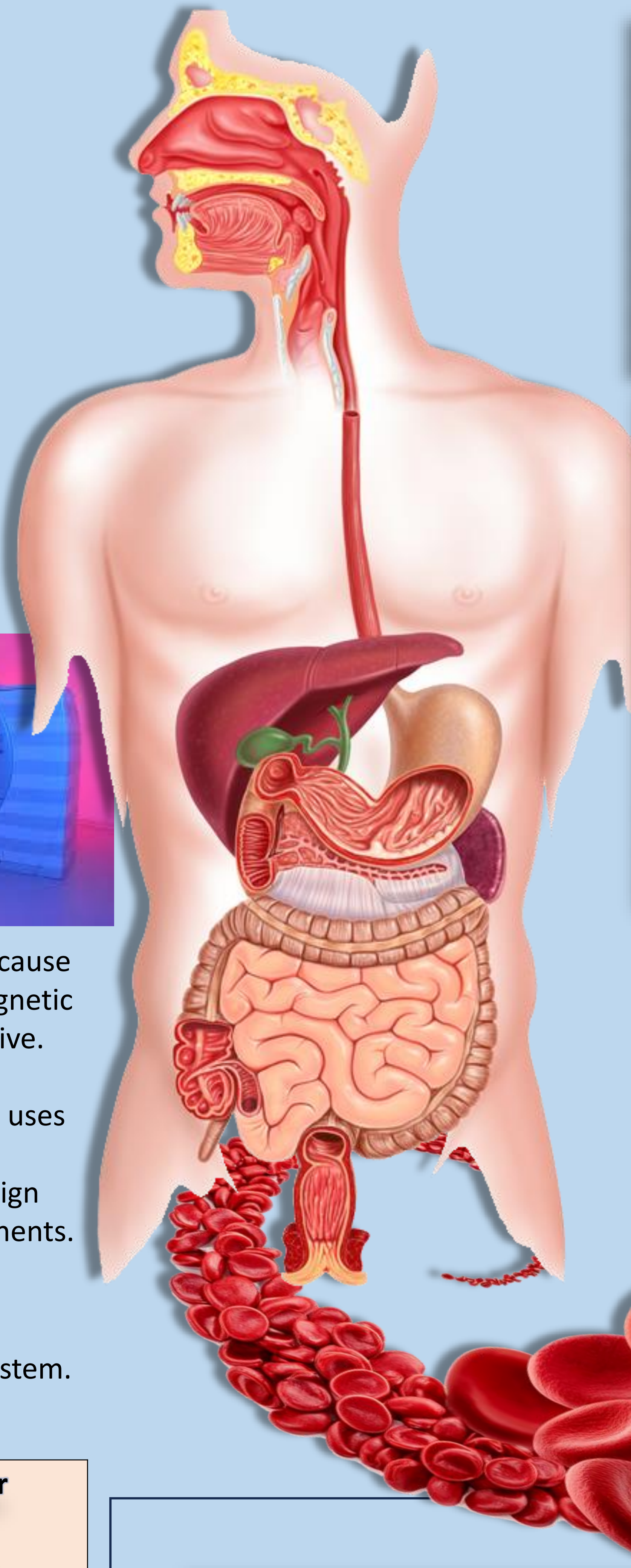
Early detection of gastrointestinal diseases are difficult to detect because current gastrointestinal diagnostic tools such as endoscopy and Magnetic Resonances Imaging (MRI) are uncomfortable, intrusive and expensive.

The capsule contains a sealed outer shell and internal electronics. It uses pH sensors and a camera to detect changes in the environment and identify objects within the test fluid. CAD modeling was used to design the internal layout, improve sealing, and properly mount all components.

Testing focuses on calibrating the sensors, studying how the device interacts with fluid, and ensuring reliable data collection. This work demonstrates the feasibility of a compact, capsule-based sensing system.

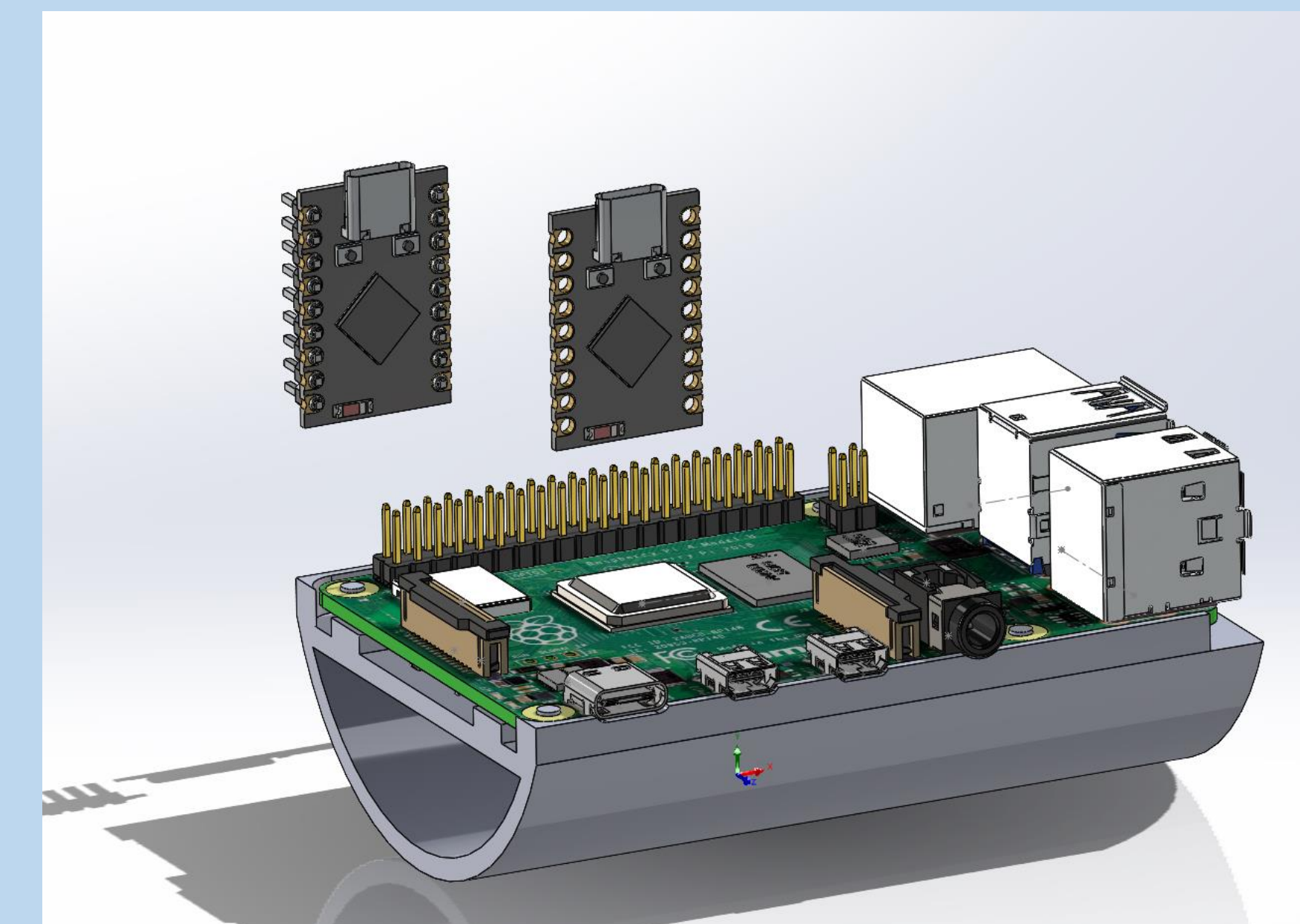
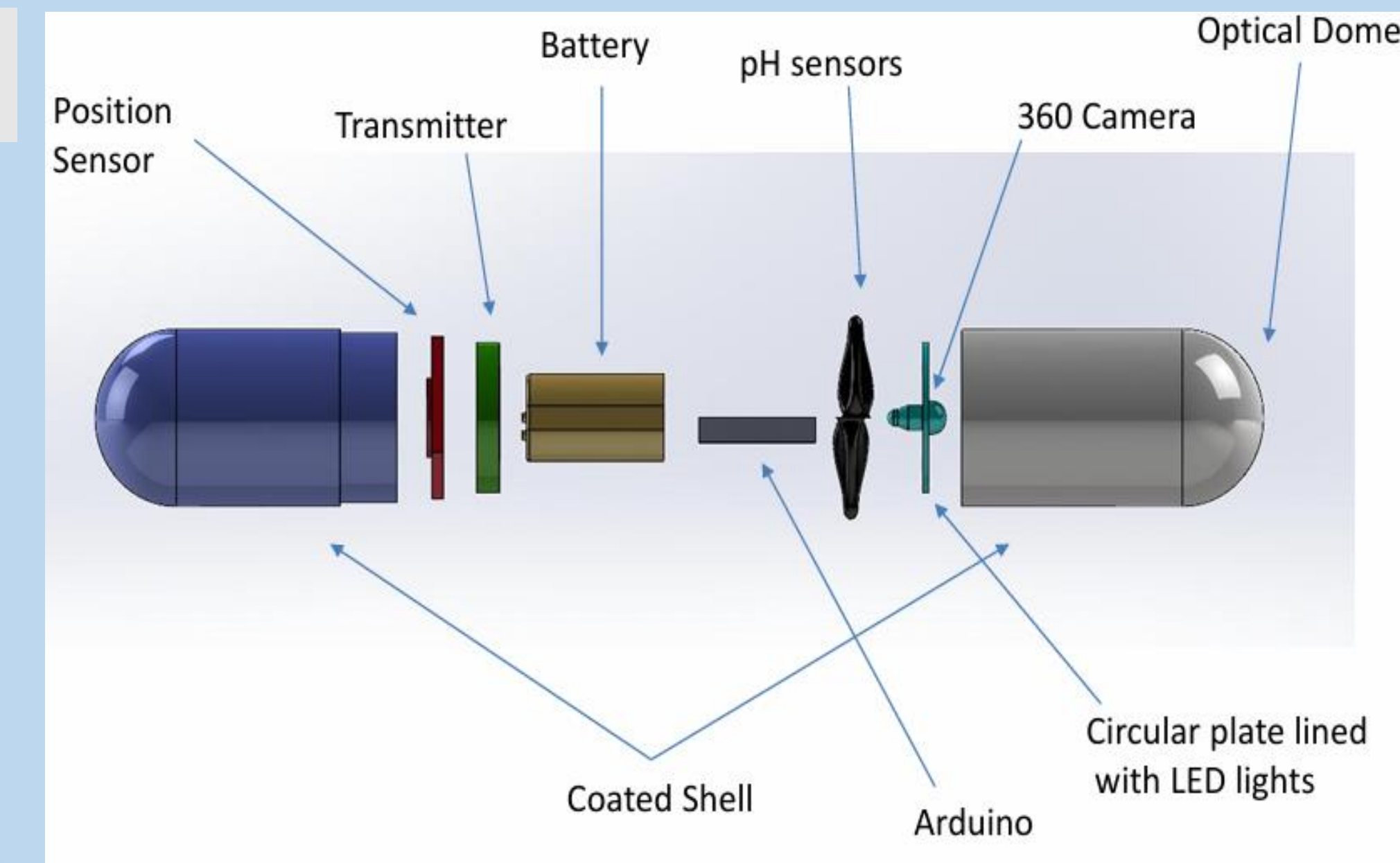
Main Hardware Options	Cost per Capsule	Complexity	Accessible for academic prototyping?
PillCam SB3	\$500	Proprietary system (capsule + recorder + software)	No, clinical-only ecosystem
EndoCapsule			
MiroCam			
OMOM	\$250	Limited, vendor-controlled	
Our Smart Capsule	~\$125	Modular, 3D-printed, rapid iteration	Designed for academic labs + education

## Control System Hardware



The tank test will include different conditions such as various pH levels, tank orientations, fluid levels, unidentified object size and positioning, as well as submersion time to ensure proper functionality of the capsule.

The prototype designs will use either a Raspberry Pi Pico or an ESP32-S3 Mini as the primary control unit. The Raspberry Pi Pico will function as a microcontroller, while the ESP32 S3 Mini offers a 2.4 GHz dual-core processor with a 240 MHz operating frequency in a compact footprint of 15.4 mm × 20.5 mm × 2.4 mm. Due to its small size and processing capabilities, the ESP32-S3 Mini is well-suited for confined form factors such as an ingestible capsule.



## Capsule Assembly and Construction

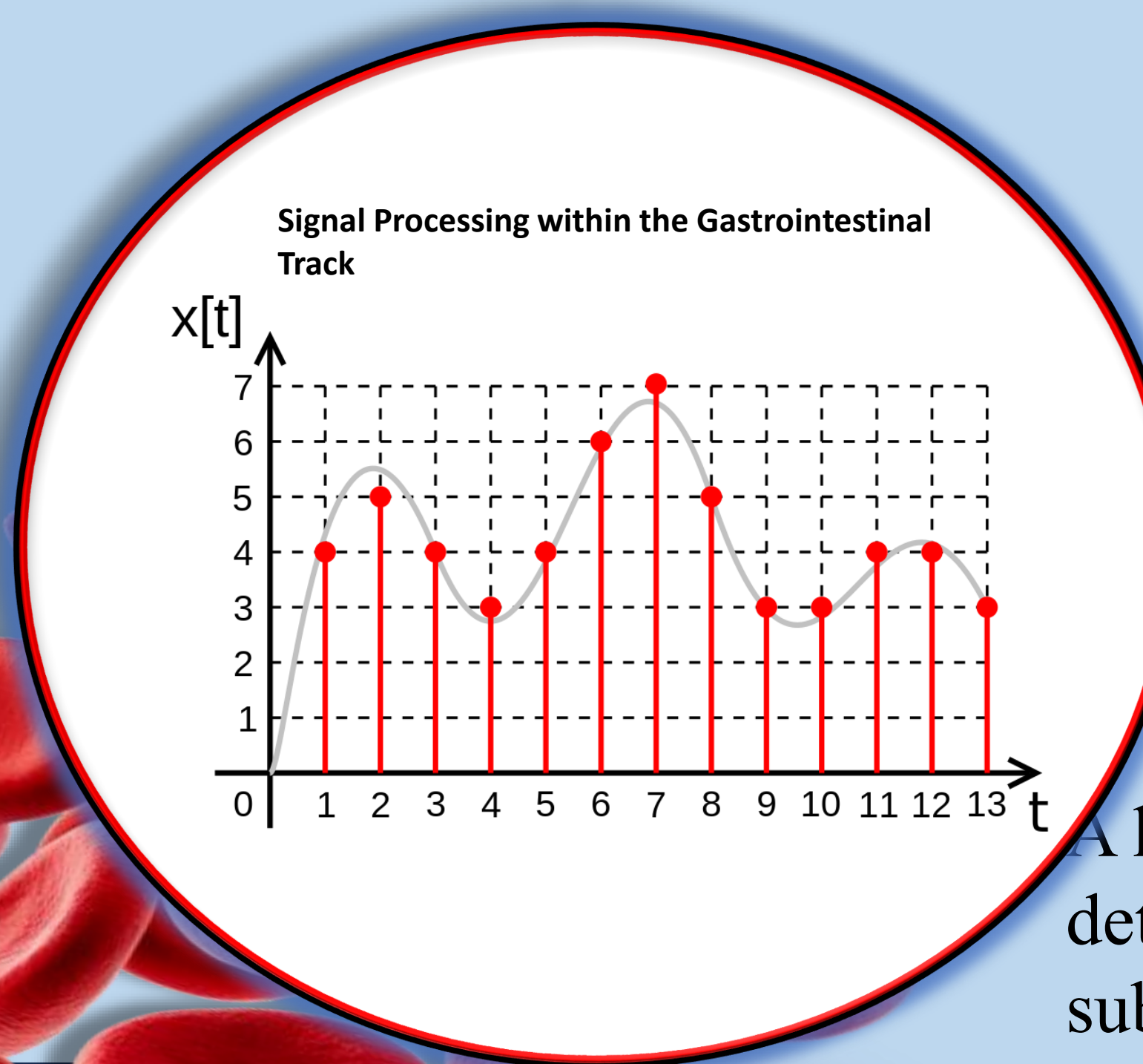
The capsule was designed using CAD software to create a two-piece sealed housing capable of operating in a viscous fluid environment. Internal components were arranged to optimize space, stability, and waterproofing. Mounting structures were incorporated to secure the electronics and sensors while maintaining structural integrity.

A Raspberry Pi is used to collect and process data from the integrated pH sensor and camera module. The electronics are assembled and tested externally before being placed inside the capsule housing. Waterproofing strategies, including sealing interfaces and controlled cable routing, are implemented to protect internal components.

## Prototyping & Waterproofing

Water Test - pill specifications:

- Material: Clear PETG
- Dimensions: 20mm diameter, 40mm long
- Weight: 3.63 grams
- Infill: 0%
- Wall thickness: 1.6mm
- Layer height: 0.2mm
- Print speed: 30 mm/s



A hollow testing pill was 3D printed and submerged in water to determine how waterproof the material used is. The pill was submerged in water for 48 hours and only received a 0.08g increase in weight.

It was concluded that a waterproof coating is not necessary and that the pill and its components will survive in a fluid environment.

